The Collins 75A-Series Receivers: A Legacy of High Quality

Part 1

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Imagine what it must have been like to be employed as a design engineer at the Collins Radio Company in early post-war Iowa, and to spend your days working on commercial radio products. It is challenging work; you are good friends with the boss. There have been chances during the war to do some original research and design, but not nearly enough to satisfy your intrinsic desire to create something really special. The Collins plant seems like a fairly good place to work, in spite of long hours, and especially with a recessionary job market just ahead. If this picture comes to mind easily, then also imagine what it must have been like to have the imposing figure of Art Collins show up unannounced in your work area, call you aside, and describe a project to you which he has in mind. As the details of his plan unfold, it turns out that you will be given your own work area and tooling. You will be charged with the goal of making the best communications receiver possible, without any restrictions or deadlines. As both you and Mr. Collins are licensed amateur operators, the prospect of having unlimited resources and an unlimited budget to develop the ultimate radio receiver must have sounded like text from a serialized "Radio Boys" adventure you might have read as a teenager. This is the situation Engineer Roy Olsen had in January of 1946.

In 1946, there was no clear idea of what the post-war world would be. Industry was changing gears - converting from war production to more civilian manufacture. In radio, as in everything else, people wanted new products, and they wanted to quickly distance themselves from the Great Depression and from WW II. The only way radio manufacturers had to establish some market share was to offer pre-war designs in shiny new cabinets, or to wait until technical ideas developed during the war could be incorporated into new products.

On the business side of radio, the pre-war style amateur market really no longer existed. The thousands of men and women who were exposed to radio communications during the war got home to find an exciting new hobby in amateur radio, and began learning time-honored techniques with the key and microphone. After a trip to the FCC district office, they added to the ranks of licensees who were active before the hostilities began. The raw material restrictions enforced later on during the Korean War had yet to take their effect, and manufacturers were generally optimistic. However, as Roy Olsen (WA6THD) points out, even though there was a prime market for radio gear right after the war was over, there were "too doggone many other pieces of equipment in the market that became surplus" to make manufacturers willing to take too much of a risk with tooling for untried equipment designs.

Excepting the Collins Radio Company, with their large staff of scientists and engineers and years of research, nobody else was in a position to really accept the risk, and to design and build the unique receiver which became the 75A. It would be best, at this point, to let the man who was there tell the story of the steps which lead to the Collins 75A-series receivers.

As Roy Olsen described it to me, "I had

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known Art on the air, 9CXX, there in Cedar Rapids, all the time that he was on. He was ahead of me by a few years, but not many. I had talked to him lots of times, and when he went into the business of becoming the Collins Radio Company, I was just graduating in 1934 as a Senior at Iowa State College in Electrical Engineering, and he knew that. As things would happen, he offered me a job. Nobody was getting a job from my graduating class, so I simply grabbed it. That's how it all started.

"The 75, without calling it A or B or anything else, was something I did actually design, electrically and mechanically. I was surprised; the 75A, at the time that I was working on it, had a proposed sales price of 375 dollars, and it was proposed to be a release of 200 units. Art was rather perceptive as to market desires. When you get right down to the capability of the receiver, it was very good in terms of frequency calibration. Its sensitivity was about as good as you could get.

"At Collins, the precursor to the 75A was the fact that I did about a year and a half to two years of study on the subject of permeability tuning, and collaborated extensively with Ted Hunter in oscillator design.

"I had a lot of fun with the 75A project, but there was a background even before that receiver. There was a 51H-1 that I built prior to the 75A. There was only one engineering prototype, and I have no idea what ever happened to it, and I don't think any others were built. Its primary purpose was to be a military general purpose communications receiver. It used a crystal-controlled first local oscillator, and a permeability-tuned second oscillator just like the later ones did. During the war, I made a presentation to the Joint Radio Board, consisting of representatives of the radio people from all the allies. They never did buy any because the end of the war came. It was a different kind of a receiver than the 75A, because it was general coverage. The 51J, and other units which came along after it, were general coverage units, and had the same frequency plan as the original I used in that first receiver. Because the 51H-1 was general coverage, it was not a receiver that the 75A could be said to be exactly patterned after. Except with the point of view of the amateur bands, basically, it became the 75A.

"For the 75A, the background came after the war when Art said 'Roy, I want you to build an amateur receiver (unspecified as to type at that time) that is the best that can be built. I don't care anything about price, and there is nothing about a schedule in terms of your ability to do it for a price, so just do it!' That's always nice when you have that kind of an option. We did already have, from the military efforts, the permeability tuning oscillators which went over the 2 to 3 megahertz range, so this gives you the option of being able to work out a calibration system that goes by whole megahertz, which is what you want anyway on a receiver dial. So that's how it all began, that's the start of it.

"That receiver, one of which I designed and made, Art grabbed the day after I had finished it. I finished up on a weekend, on a Saturday, and took it home with me on Saturday night to try out. Sunday morning at 10:00 AM, Art came over to my house and said, "Roy, where's that 75A? I want to put it on the air!" I never saw it again. That's typical of Art by the way. Following that, I left the company and other people carried on with what became 75A-1, 2,3, and 4. The basic design I did lay out, I did do, but I really never saw, or even used, any of the other ones after that. I don't think the 75A ever became a widely spread thing, although the initial release on it was 200 units. I think the actual development on the receiver itself took about six months."

I asked Roy how Art Collins came up with the 75A designator, as we all have been wondering about this for years. His answer was pretty much to the point:

"You'll never know, and I'll never know. Numbers like that came out of Art Collins' head and went to the Great Beyond with him. Sometimes, of course, for military equipment like ART-13, there was a clear derivation of military nomenclature itself, but otherwise, who knows? I didn't know 'a number' during all of the development of the 75A, until it was structurally and physically 'in being', and Art came over and grabbed it."

The Invention of Linear Tuning

One who is new to thermionic technology might well wonder what's so darn unique about Collins receivers. There are two words, stability and accuracy, which best define the receiver Roy Olsen built from his 51H prototype.

Stability in a high-frequency crystal oscillator is relatively easy to achieve. Also, stability in a low-frequency VFO is commonplace. It's one of those ideas where one might say "how come nobody thought of that before?" when Roy Olsen married the two. He included into the design a high-Q RF preselector, a high-Q tuneable first IF, and linear permeability tuned and precisely-tracked RF stages. These unique features made the 75A series receivers the revolutionary success that they were. Even today, although HF communications equipment is controlled by more complicated circuits, most of them follow the conversion scheme laid out by Roy Olsen for his 75A with a crystal-controlled first IF.

Because of the linear, permeability tuned VFO, and its unit-to-unit uniformity, a receiver could have, for the very first time, a dial with readout accurate to less than one kilocycle. Because of Collins' advanced manufacturing techniques and attention to detail, calibration was retained year after year. For the first time, an operator knew where he was listening, without guesswork. He knew, just by looking at the dial, if both of his sidebands were in a legal area.

Aside from the idea of using a crystal-controlled first IF to establish overall receiver stability, the real heart of the 75A was linear permeability tuning. Roy Olsen invented it, and had patents granted in several areas. The concept came out of two years of research at Cedar Rapids, but I'll let Roy tell the story, as it was related to me:

".... I knew Ted Hunter very well. I worked with him for years. Ted was a hard worker and a fine engineer and was the person who did the first of the pressurized permeability tuners, but the idea of making a linear tuning system came from me.

"Mostly, permeability tuning was something that I didn't know how to do theoretically. I still don't know anybody who knows how to do it theoretically, but I found the technique as a result of thousands and thousands of tries. I finally developed the idea of a linear ratio of a 2:1 in frequency change. In fact, the idea went into several of the prototype Collins receivers. The problem was that we wanted to operate, usually, over one megahertz simply because the oscillator went in a 2:3 ratio. I had to use multipliers of the same ratio as the frequency went up. As long as I kept that initial ratio and multiplied the oscillator source frequency by the same ratio, the oscillator and the coil tuning, which is usually the antenna tuner, or RF tuning, would track. That was the original concept for the system. Initially, I took a core with the frequency characteristic needed, and a coil with a 2:1 length-to-diameter ratio; that's the first requirement. Then, take a core that fits in that coil, with a diameter ratio that depends only on how wide a frequency range you want to cover, excepting that you can't do it over more than about 2:1. Then, you take a similar core and intrude it into the back end of the coil. If the motion of the slug is limited to approximately one half of the total possible penetration, then the core may be moved back and forth until a very, very close approximation to linear frequency response can be found, with a uniformly wound coil. The real problem

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with linear tuning is just the same as it is with many others: you have a concept that you can make a system quite linear, but it is never quite as linear as you'd like to have it.

"It's very interesting that even on a ceramic form, it's difficult to fire a changed-pitched coil in order to make it linear. There is grain to the structure of even the best ceramics, and even much more so on coil forms that are phenolic in any form. The problem became, quickly, one that you had to identify what the change in frequency would be resulting from using one or another type of coil form wound with different materials, or whether just the rotary orientation of the coil form was producing the error. It gets pretty tough to make these coils in quantity production, and it was Ted who brought that to real fruition.

"Ted developed an idea of using a stack of washers that had a cam running on them which gave us the corrections for a few hundred cycles of oscillator error, and that was incorporated into the series of permeability tuned oscillators. The real problem up to then was stability. It was Ted who did all the hard work as to the temperature coefficients of all the pieces, the capacitors, inductors, and metals.

"I had the same problem, exactly, in the oscillator on the ART-13. On that one, it was solved by Collins having girls who had all the measuring equipment necessary to display the curves of the oscillators as they ran back and forth over the compensation washers. They got so good at it that they could just watch the cam that was doing the correction and adjust the washers with their fingers.

"The other problem is how do you make a tuning shaft that is, in parts per million, accurate? We found that answer, eventually, in an imported Swiss lathe. I didn't have anything to do with that particular part of it, Ted did all that. He should be given credit for every part of it excepting the fact that I designed and had been making linear tuning elements."

(America's competitive edge will be lost forever if we can not find a way to educate more outstanding engineers like Roy Olsen.)

Production of the 75A

Now for the hard question: Were there ever any Collins 75A receivers actually produced?

As nearly as I can determine, the answer is that there were. Roy Olsen has said that the initial release was 200 units. I feel that this initial figure was cut way back, and that far fewer than 200 were actually produced.

I researched back issues of QST, looking at product announcements, and for anyone who might have had one for sale in the ham ads. The original product announcement came out in October, 1946. There are photos of 75As in the Collins ad for February, March, May, and June of 1947. Included in these photos is Clyde Hendrix (WØHBG), Art Collins' friend, at his brand new 75A/30K station in the May ad. The ARRL lab had a sample, and it was reviewed for the September 1947 issue. Photos of the receiver chassis in the ARRL article match photos in the Collins 75A sales brochure. Suddenly, they stopped mentioning the 75A. Nothing was said of any receiver until November, when it was announced that Collins has "reinstated direct sales", and showed a 75A-1 in the equipment list. All of the various dealer ads after November, even though they call out a "75A" receiver, have photos of the 75A-1. The only QST "ham ad" for a 75A I could find (I searched until mid-1953) was in May 1947 when a "Craig" in Salem, Oregon, began to advertise, wanting one. He found it, as he had it for sale again in "new condition" in September of that same year. If you are out there Craig, please contact Electric Radio Magazine!

In discussing this matter with Gene Senti, I learned that it was typical for Art Collins to send about two dozen units of a new production model to his best dealers and personal friends for evaluation.

There is photographic evidence of a few differences between the 75A and the 75A-1. I feel that Art Collins probably held off on full production until the results of the evaluations could be built into what became the 75A-1. Next month, when the 75A-1 is discussed, we'll get into these differences, so that maybe some sharp-eyed reader may be able to actually find a genuine Collins 75A. **ER**

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14) Items 1, 2, 8 and 9 were already installed in my NC-300.

The fast attack/slow decay modification is not quite as fast as the '303's because R24 is in series with the AGC line. With R24 shorted out AGC action is the same. But, the circuit I show here is only a few milliseconds slower and can be made without any other major modifications. There are no pops or blasting evident in the audio and a side by side comparison between the NC-303 and the updated NC-300 showed no discernible difference in any mode SSB, AM, or CW strong or weak.

The only other modification I didn't add to my '300 was to replace the 2295 Kc 2nd conversion oscillator with a xtal oscillator. This can be done in your NC-300 if you're experiencing drift in your rig. I understand in humid areas this is a problem. See the CQ article above for details. My NC-300 was just fine.

This completes the changes I found necessary to make my NC-300 perform much like the NC-303 on SSB while not affecting the AM or CW performance.

The SSB reception is now excellent, just what I need for a vintage SSB/AM station. The NC-300's can be purchased very reasonably compared to the NC-303. Stability is the same in both rigs and, in my estimation, with this update the '300 is as good as the '303 for SSB audio quality.

Good luck, see you on the vintage SSB net. **ER**

Classic Radio Exchange

Scheduled for 2000 to 0400Z September 27 and 28, the Classic Exchange (CX) is a celebration of the older commercial and homebrew equipment that was the pride of our ham shacks just a few, short decades ago. The object of the contest is to restore, operate and enjoy older equipment with like-minded amateurs. A "classic" radio is at least 10 years old, an advantage but not required to operate CX. You can use anything, although new gear is a distinct scoring liability and not as much fun!

Exchange: Exchange your name, RST, QTH, receiver and transmitter type (homebrew send final amp tube or transistor) and other interesting conversation. The same station may be worked with different equipment combinations on each band and each mode. CW call "CQ CX"; phone call "CQ Classic Exchange." Nonparticipants may be worked for credit.

Suggested frequencies: CW-up 60 kHz from low band edges; phone- 3880, 7290, 14280 and 21380; Novice/Tech - 20 kHz up from low band edges. 7060 and 3560 tend to be the most popular CX frequencies.

Scoring: Multiply total QSOs (all bands and modes) by the following sum: total number of different receivers and transmitters worked on each band and mode plus the total number of states/provinces/countries worked on each band and mode. Multiply that total by your "classic multiplier": the total age in years of all receivers and transmitters used, three QSOs minimum per unit to qualify. If equipment is a transceiver, multiply age by two. If homebrew, count as 25 years old unless actual construction date or design is older.

Awards: Certificates are awarded every now and then for the highest score, exotic equipment, the best excuse, and other unusual achievements.

Logs: Send logs, comments, anecdotes and pictures to Jim Hanlon, W8KGI, P.O. Box 581, Sandia Park, NM 87047 or Marty Reynolds, AA4RM, P.O. Box 13354, Atlanta, GA 30324. Include SASE for the next CX Newsletter.

The Collins 75A-Series Receivers: A Legacy of High Quality

Part 2, the 75A-1

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1948 was the first full year of production for the revolutionary new Collins 75A-1 receiver, advertised as the "first really new design since the introduction the superheterodyne. As only a few of us were active in 1948, perhaps a quick review of that year would be in order before going on with the 75A story.

The state of the radio art in those times had been fast changing, and was witnessed by many operators. It was hard to believe that it had been just 25 years since the first trans-Atlantic amateur QSO. The three operators involved with that pioneering 100-meter contact, Leon Deloy (F8AB), John Reinartz (W3RB), and Fred Schnell (W9UZ), were still alive and working, but Deloy was no longer licensed.

The 1947-1948 period was at the peak of solar cycle 18, and it was an excellent time to be on the air with a hot new receiver. VHF'ers were hoping for the MUF to hit 50 Mc., but use of the new 15-meter band had not yet been authorized. Various amateurs were conducting propagation studies up there. Television interference was starting to become a major problem for the amateur community. Designs were published where an entire transmitter was built up enclosed in copper shielding screens. As a public relations gesture, Hallicrafters donated one of their model T-54 television receivers to the ARRL lab. The ARRL was investigating various TV sets, so that the effects that an amateur 15-meter transmitter would have on a TV 21 Mc. sound IF channel could be predicted.

There were lots of published plans for rotary beam antennas, but most of the 80,000 licensed hams didn't have one. High-power amplifiers were not as common, either. A fixed flattop wire beam was much more common. Steel towers were rare, but there were some homebrew wooden towers. The Quad antenna was introduced in November '48, having been invented at HCJB in Quito, Ecuador a little earlier. For the DX man, more and more countries were once again allowing radio operations. The surviving overseas operators were forced to go on the air with whatever simple materials they could lash together. A July, 1948 DX'pedition to semi-rare Nassau, Bahamas (then VP7) described using a length of lamp cord hanging out of the hotel window as their main antenna! These styles of operation meant that for a DX'er, receiver sensitivity was one of the most important specifications. Receiver dynamic range numbers were unheard of at this time. Generally, problems with receiver cross-modulation were still confined to areas of the country where there were lots of hams in a small area, or to a field day site.

In one of the most prophetic articles of the post-war era, Byron Goodman introduced the transistor as an "amplifying crystal" in October 1948 QST. His closing remarks mentioned, in part, that "these clever little devices are well worth keeping an eye on."

Nearly every issue of every amateur magazine had at least one monthly article dealing with the merits of single-sideband or narrow-band FM. The storm of controversy surrounding SSB was evident by the volume of letters from the readers. Another hot topic was the value of coax feedline vs tuned feeders.

Collins 75A-1 receiver.

For members of the ARRL, a sad event was the passing of Ken Warner, W1EH, in September, one of the real old-timers.

Production Of The 75A-1

It was under these conditions that engineer Lou Couillard took the initial 75A receiver design, merged it with what was learned from the field samples, and produced what we knew today as the 75A-1. At Collins, Mr. Couillard went on to become the project team leader for the R-390 receiver in 1949.

I have been unable to find an original schematic for the 75A design, so some speculation is necessary. Looking at the 75A-1 front panel (Figure 1), it is obvious that a noise limiter switch has been added. In the original design, the limiter was in-line at all times, which possibly lead to comments of audio distortion on strong signals. From photographs of the 74A bottom view (Figure 2), and the 75A-1 bottom view (Figure 3) several other changes are evident. Exchanged were the positions of four power supply components, L28/C84, and V14/L29. This move placed the hot rectifier tube to the outside of the chassis, near the cabinet vents, and away from the BFO components. This might have been done to cure some degree of BFO instability. It also looks like C84, the filter condenser, was changed from an octal base plug-in unit to a more typical (and less costly) twist-loc type. There may have been a problem with feedback in the power supply, because an aluminum shield was added between the power supply section and the IF strip. In the front end, the crystal oscillator tube was moved physically closer to the first mixer, and one of the sealed, oil-filled bypass condensers along the left edge of the cabinet was removed. In view of these differences, it is unlikely that a 75A would have been converted to a 75A-1 without a major rebuild, as a chassis change-out

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would have been necessary. What is more likely is that an unsold 75A may have had a serial number plate installed with a 75A-1 model designator!

Circuitry

On a Collins 75A-1 receiver, tuning around with the VFO knob also tunes the entire front-end. The VFO is slug-tuned, and all the slugs in the system are matched to variable pitch coils. The entire tuning system is thus made linear. With so many stages tracking together, system Q and overall selectivity are maintained at a high level. Ed Andrade, the designer of the Collins S-line receiver, points out that the 75A-series receivers, with their tuneable first IF and a tracking RF preselector, actually have greater immunity to out-of-band energy than the later S-line units.

The grid and plate circuits of the RF amplifier, the first mixer, and the first IF amplifier stage are ganged together and tuned via the gear-driven slug rack. Actually, only the 80-meter coil slug in the RF amplifier grid and plate circuits is driven from the slug rack. When the bandswitch is operated, additional parallel resonant circuits are switched in parallel with the 80-meter network as necessary to change the RF tuned frequency. This maintains the same value of Q over all band ranges. For the time, this was a unique method of bandswitching. The bandswitch also turns on a separate set of lamps for every band to illuminate the slide rule dial, a very attractive feature.

The RF amplifier used is a 6AK5 pentode. This is a very sharp cutoff tube originally designed for wide-band UHF amplifiers during the war. It has very high gain and an equivalent noise resistance (ENR) of 1700 ohms. Delayed AGC is applied to its control grid, which makes the RF stage susceptible to distortion in the modern environment. In 1948, it was a logical choice, as they were after high sensitivity.

The RF preselector feeds a 6SA7 first mixer, using a separate oscillator tube and high-side injection. The 6SA7 is hard to overload, but is very noisy. Most of the wide-band "hiss" in the A-1 comes from it. With an ENR of 247K ohms, the 6AK5 RF amp has trouble overriding this much shot noise above 20 meters. (Owners of 75A-1s should always keep a "strong" 6AK5 in their receivers). The 6SA7 was largely replaced in the industry with the miniature 6BE6, and was listed by the late '50s for replacement purposes only.

The first IF amplifier has a bandpass of 2.5 to 1.5 Mc. when the receiver is tuned on the 80-to-15 meter bands, and 5.5 to 3.5 Mc. on the 11-and 10-meter bands. These frequencies were chosen as a "best compromise" in avoiding harmonic response, yet the use of a high first IF yields an image rejection ratio on 10 meters of 50 dB with only one RF stage. The IF amplifier tube chosen was the very remote cutoff 6SK7 pentode, which is noted for its near total immunity to cross-modulation. It takes -35 volts of bias to cut the plate current off. Unfortunately, as we know now, most of the distortion in receivers occurs long before the IF amplifier. The 6SK7 is fairly quiet, at 11K ohms ENR, but there is already plenty of signal and noise coming into its signal grid and the low-noise characteristic isn't of much advantage here.

The second mixer is the old faithful 6L7. It gets its oscillator injection voltage from the 70E-7 PTO. It's a good thing that the 6L7 is not used in earlier stages, as it is an extremely noisy tube at 395K ohms of ENR. When the receiver is tuned in the 80-to 15-meter bands, the PTO fundamental of 2 to 3 Mc. is used for low-side mixer injection. When tuned in the 11- or 10-meter band, the second harmonic of the PTO is used for high-side injection. This is another example of Roy Olsen's unique design work, which minimizes harmonic response and at the same time provides a fixed 500 Kc. IF to develop high selectivity.

A conventional crystal filter follows the 6L7. It is very effective and meets all Collins specifications. Judged by "cali-

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brated ear", changing filter bandwidth does change gain through the filter stage, but not by as much as with other receivers.

Following the crystal filter are two stages of conventional IF amplification. The amplifiers use 6SG7s, which are semi-remote cutoff pentodes having an ENR of about 3.2K ohms with the current ratios used in these stages.

A self-adjusting series type noise limiter is coupled to the detector load resistor, so that the detector always clips positive and negative peaks that exceed 35 percent audio modulation. This circuit was developed during the war, and had not been used before in amateur gear. It was shown in every ARRL handbook thereafter for about 25 years!

A fairly unique system of amplified AVC is used in the 75A-1. A fixed bias voltage is placed on the cathode of the AVC tube (6SJ7 pentode). This voltage corresponds to the amount of delay that was deemed necessary to avoid AVC action on weak signals. The plate is coupled to the IF, and when the IF voltage is higher than the bias on the cathode, the tube turns into a rectifier. AVC bias voltage then appears on the AVC line and is applied to all gain-controlled stages, and to the S-meter. AVC is not available on the CW and SSB modes, as BFO energy would capture the AVC rectifier. A 100 dB change in RF input causes a 5 dB change in audio output, which is impressive performance.

The BFO panel markings are accurate enough to be used to determine a received signal frequency, which also had not been done before.

The remainder of the 75A-1 is conventional and won't be discussed, except to note that the output tube is a 6V6, running at 8 to 10 percent total harmonic distortion at 2.5 watts output.

Construction And Performance Data

The evaluation receiver in the photographs (S/N 1822) was supplied through the courtesy of George Maier (KU1R). George did a magnificent job restoring it to operating condition. He obtained it from Dale (KW1I), who bought it some time ago at the Deerfield swap meet. One of its early owners, possibly the original, was F. Mazza, W2KHG.

Collins' high quality construction standards are obvious when looking at this receiver removed from its cabinet. The chassis is built up from several individual sections, which is labor-intensive but very strong. The 75A-1 has tighter shielding and higher quality components than in the later receivers. The bandswitch extends into separate shielded compartments, and there is shielding fingerstock between the ends of the shield sections and the side walls! Every stage is bypassed with sealed, oil-filled, multi-section condensers. These are mil-spec units which will last several lifetimes. The power supply filter, although grounded through its mounting hardware, has an additional ground lug which is soldered to the shield wall between the power supply and the IF strip. High quality Allen-Bradley type "J" sealed pots are used for AF and RF gain controls, and are even installed on the little used S-meter adjustments. This is truly deluxe construction, as these pots rarely break down or get noisy. Just like the advertisement says, no control on the front panel changes the received frequency except for the tuning knob.

In the minus category, the hum level is too high to suit me. I replaced the filter condenser, but the hum remains. The limiter introduces distortion with strong signals because the clipping level isn't adjustable, and pops and clicks are still strong enough to hurt your ears with the "cans" on. There is too much play in the 75A-1 slug rack, and alignment can be affected by end play. This was eliminated, starting with the 75A-2 receiver.

I did a full alignment in order to do the performance test, and made no improvement over KU1R's alignment. I discovered a few items worth mentioning, how-

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ever. A good place to attach a VTVM for an alignment "looker" is an unused terminal (#4) on the IF output transformer, T4. I put a little Stabilant 22 (see ER index) on all the core slug threads. This made the adjustment smooth and easy. I discovered that the "S" meter is nowhere near accurate, as a 6 dB change in generator level dropped the meter needle 30 dB.

I found a more accurate crystal filter alignment method than stated in the manual. It turns out that as time passes, the center frequency of the filter crystal changes. To compensate, it is necessary to accurately determine center frequency. To do this, attach the VTVM to the above mentioned point, and with the filter in its most narrow position, slowly rock the signal generator across the passband and note the exact frequency where the crystal filter response peaks sharply. Measure the generator output frequency, and use this new frequency in the book's alignment procedure. When doing the alignment the bottom filter transformer adjustment is easier to get to than the top one. Also, alignment instructions for T1 are not given in the book. Align it for maximum output, using the newly discovered crystal center frequency.

If the dial calibration is out of tolerance, and the end-point adjustment has run out of room, but the mid-range is still fairly linear, there is a procedure which might bring it back into alignment. (You will need an accurate, stable, 14.0000 Mc. signal source or a good 100 Kc. calibrator which has been set to zero with WWV.) First, center the dial fiducial in the kilocycle window. On the 20-meter band, tune up to 15 Mc., and leave the kilocycle dial calibration mark even with the fiducial center line. Loosen the PTO shaft coupler, and without moving the plastic Kc dial, manually turn the PTO shaft to center WWV in the passband. Tighten the coupler, tune down to 14.000 Mc., and use the end point adjustment to center the calibrator signal. This will need to be repeated many times. Each time it is done, the error gets less, and it should eventually bring the PTO back into line. When finished, realign the front end.

The electrical performance of the 75A-1 was measured. Its minimum discernible signal, with the crystal filter in position 1, is -137 dBm, or .031 microvolts. The 75A-1 will show a 10 dB signal-to-noise ratio with an input signal of .1 microvolt. The single-tone blocking dynamic range measured a respectable 82 dB. The 3rd-order, two-tone dynamic range is, as expected, somewhat less at 72 dB. Cold start drift was never more than +430 cycles, and long-term drift settles down to +- 32 cycles. Sharp blows on the bench top don't affect a beat note at all. Varying the line voltage from 105 to 130 volts changed a beat note by only 55 cycles.

Development of the "ultimate receiver" did not stop with the 75A-1. Yet to come were many improvements in circuit design, and the phenomenal mechanical filter. We'll trace these changes starting next month, with the 75A-2's introduction. **ER**

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Part 3, the 75A-2 and the 1950's

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In the summer of 1949, certain events were taking place at the Collins Radio Company. The engineers who were in charge of system planning were beginning to realize that the future of HF voice communications systems was probably going to be with the single sideband mode. However, the hardware necessary to build practical systems was still in a rather 'raw' state, and the few working systems required multiple racks of equipment space. The Engineering and Sales departments at Collins were determined to command a leading position in the radio field, and the Amateur Equipment department was no exception. They wanted to introduce equipment at the start of the new decade which had the highest possible quality. They also wanted the highest possible potential for spin-off, as many hams at that time were employed in radio at the professional level. These various factors meant that the new amateur equipment introductions would be high quality AM transmitters and receivers.

The legendary KW-1 AM transmitter had been prototyped, tested, and was scheduled for introduction some time in mid-1950. As part of a general new equipment sales drive, the 75A-1 was again turned over to engineer Lou Couillard for an upgrade, to be timed to coincide with the introduction of the high-power voice of the KW-1.

The 75A-2 product announcement occurred in July of 1950. Almost before the ink on the July copies of the ham magazines was dry, the Korean War broke out, June 25, 1950. There is no way that Collins could have foreseen that the nearly immediate commitment of UN forces to the battle over the 38th parallel would affect schedules in the entire product line. Collins Radio was one of the most essential defense contractors in the country.

In spite of the Controlled Materials Plan, and a very uncertain world situation, production of the new receiver began. It continued unsteadily throughout that summer and fall of 1950. By November, 1950, there were prototype 75A-2s ready for shipment to various dealers for new product evaluation. Finally, in February and March 1951, comments from the dealer samples had been incorporated into the design, and full production was initiated.

Due to the on-again, off-again nature of amateur equipment production in late '51 and early '52, rumors began to circulate that Collins was going to get out of the amateur equipment field altogether. It got loud enough that Mr. Collins was forced to devote the December, 1950 full-page QST ad to "rumor control", and officially state that he had no intention of quitting. (After all, the boss was a DX'er!)

There was some concern that we would again lose operating privileges as the Korean conflict escalated. The U.S. Army began to use portions of the 80-meter band while on maneuvers in South Carolina in August, 1951. We would have done our duty and become silent, but it fortunately turned out to not be necessary.

Finally, the dealers began to see a more consistent delivery schedule from Iowa. An ad in October, 1951 QST proudly announced that "your KW-1 is on the way!"

Figure 1, Collins 75A-2, from the station of O.J. Jenkins, KØOJ.

Circuit Design Of The 75A-2

In March of 1949, we unexpectedly regained partial use of our pre-war 160-meter band. So, Lou Couillard made sure his design for the 75A-2 included 160.

The 1947 International Radio Conference granted amateurs new bandwidth at 15 meters. Although use of 21 Mcs. was not permitted until May 1, 1952, both the 75A-1 and 75A-2 had full 15-meter coverage. This conference granted many new assignments at HF to the international services. Broadcasters, press wireless services, the military, and others had new allocations and higher power requirements, as HF was the prime international communications medium at the time. Amateurs gained 15-meter assignments, but we lost the 14.350 to 14.400 segment which was re-allocated to commercial services. What this meant to amateurs was a huge increase in the number of close-in, high-power transmitters.

The most noticeable cosmetic change to the new 75A-2 was the tuning dial. Gone was the slide-rule dial with its band-in-use illumination. In its place was the drum-type megacycle dial which characterized these receivers until discontinuation of the A-line equipment in 1959. Other changes included punching a chassis hole at the rear for an SO-239 coaxial antenna connector, as unbalanced coax feedline was beginning to win out over balanced feeders.

Nothing was radically changed in circuit design from the way Roy Olsen laid the 75A receiver out. There were design changes to the front end, the AVC circuitry, the crystal filter, and separate phone and CW noise limiters were added.

The "early series" 75A-2s had a front end which used a 6AK5 RF amplifier (as in the 75A-1), and 6BE6s for 1st and 2nd mixers. Seemingly overnight, there was an explosion of high-powered users adjacent to our bands. In addition, there was

continued next page

Collins 75A-Series from previous page
a substantial increase in the number of linear amplifiers and rotatable beam antennas on higher towers at amateur stations. This created the "new" technical problems of intermodulation distortion (especially 3rd order mixing), cross modulation, and receiver blocking. The situation grew steadily worse, finally becoming severe enough that the entire front end of the 75A-2 was re-designed in late 1951. These are known as the "late model" 75A-2s.

The late-model 75A-2s used 6BA7s for both mixers, with the fixed bias carefully adjusted so that the mixers spent as much time as possible in the linear region. These later A-2s also changed to an AGC-controlled 6CB6 RF amplifier. This tube was developed in the early fifties for TV service, being used in tuners and IF amplifiers. It has a transconductance of 8000 microhos and an equivalent noise resistance of just 1094 ohms, so it has high gain and is quiet. It has low interelectrode capacity, and is not subject to parasitic oscillation. It has a very sharp cut-off characteristic, however, requiring -4 volts or so to cut it off, which is nearly half of what is required to cut off the 6AK5. With this kind of characteristic, it is hard to understand how Mr. Couillard expected this tube to provide an improvement over the 6AK5 in reduction of distortion. In a July, 1955, QST article by Collins Engineers Ed Andrade (WØDAN) and Ernie Pappenfus (WØSYF), this conflict is alluded to. The authors recommend changing to a 6DC6 or a 6BZ6, which were recently developed to be resistant to blocking and distortion in the presence of strong signals. This article also advises a change to a 6BA7 mixer, as the 6BA7 is quieter by a factor of nearly three.

Looking on down the lineup, the next change to come was the elimination of the IF amplifier in the 1st variable IF. This was likely done to keep the gain ahead of the mixers as low as possible, so that they remain in the linear region as long as possible. Crystal filter effectiveness is greatly reduced when the filter is overloaded, and spurious responses can be introduced. Therefore, the main gain-producing stages in the A-2 occur after the selectivity is established.

To further improve overall stability, the crystal-controlled first oscillator was re-designed. It had been a 6AK5 pentode in a modified Colpitts electron-coupled oscillator, which is typically very stable when used in the fundamental or overtone modes. Couillard's new design used a 12AT7 in a modified Butler series-mode oscillator. This type of oscillator had been used in VHF equipment, and was noted for high stability and purity of output. Basically, a Butler oscillator is a grounded-grid class-C amplifier with controlled feedback. The plate and cathode currents are equal. A Butler oscillator can be used on a crystal fundamental, or any overtone. The use of this circuitry in an HF receiver was unusual, if not unique, and is a good example of Collins engineers using advanced circuitry to improve product performance.

The tuneable second oscillator (the PTO) was changed to an improved type 70E-12, tuning 1.955 to 2.955 Mc. This new injection frequency was required because the fixed IF was changed to 455 Kc. As before, the second harmonic of the PTO is selected when tuning in the 11 and 10-meter bands.

Directly following the second mixer is a slightly redesigned crystal filter. The phasing control capacitor is connected to the filter crystal in a balanced bridge arrangement, with resistors switch-selected in series with the phasing capacitor rotor to vary the total filter Q, and hence its bandwidth. Using this approach gives a filter with a phasing range down to 250 cycles or less, but with only a 6 dB gain reduction in its sharpest selectivity position. A special phasing capacitor is used which has an extra set of stator plates to avoid detuning the coupling transformer. Again, Collins provided enhanced performance by refining an established design.

A three-stage 6BA6 IF amplifier strip is

next. This is the main gain-producing stage in the receiver, but since the receiver selectivity has been already established by the crystal filter, the IF transformers need only provide interstage coupling. That's why there are 5 and 10 mmf mica condensers connecting the primary and secondary windings to increase gain. A procedure in the manual outlines removing these coupling components to narrow-band the receiver's IF.

A miniature 6AL5 double-diode is used as a conventional detector and AGC rectifier. A triode half of a 12AX7 is used as a DC amplifier for amplified AGC control. A positive bias is placed on the DC amplifier control grid for delayed AGC action. There is a degenerative R-C network in the AGC amplifier plate circuit to keep it from responding to audio frequencies. The 75A-2 "S" meter works in all modes, as it is connected in a bridging circuit between the last IF amplifier cathode and the screen supplies of the first two IF amplifiers.

New, dual noise limiters were built into the 75A-2. For phone operation, positive noise spikes were assumed to be automatically clipped by detector limiting, due to the heavy loading on the detector diode. Then, a series-type noise limiter (half of a 6AL5 double-diode) is used to limit the negative peaks, beginning at signals with 35% modulation. The limiting level is not adjustable from the front panel, but a limiter cut-out switch is provided. On CW, a dual shunt-type limiter shorts out noise pulses on both positive and negative peaks which exceed the operator's preset levels.

75A-2 Electrical Performance

The evaluation receiver in the photos was very nearly original, having had only two capacitors replaced in all its years of faithful service. In order to do the usual performance tests, I gave it a full alignment, checked the tubes, etc.

The receiver noise floor measured an astounding -141 dBm, and is probably due to the high-transconductance 6CB6 RF amplifier. This result was checked and repeated three times in succession. This equals a receiver input of .06 uV for a 10 dB signal-to-noise ratio.

Proceeding with the dynamic range tests, I discovered something rather unusual. The single-tone blocking dynamic range measured 56 dB at 20 Kc. signal separation. However, when the 1-dB gain reduction point is reached, any further increase in signal input power caused the receiver to completely block up and collapse into silence. This remained until all of the input signals were removed. Other owners of 75A-2s have reported no particular problem with blocking in high-signal environments. Since this was not my receiver, I could not start changing components, but voltage and resistance checks showed everything to be within 20%. I am at a loss to explain this behavior, and input from other owners is encouraged!

I went on to the 2-tone IMD tests, and found more "strangeness". The 3rd-order dynamic range measured 82 dB, 26 dB higher than the single-tone range. The tests were repeated three times, each time with the same result. I have never checked any receiver where the 2-tone dynamic range is higher than single-tone, commercial or amateur. I'm not sure that I even believe these results, but they were repeatable.

Conclusion

The 75A-2 was introduced in some rather challenging technical times. New requirements were testing the receiver designer's ingenuity faster than ever before. Advancements in tube design were depended upon to solve many of these problems. Collins balanced many engineering trade-offs in making design choices, and managed to adapt quicker than many other manufacturers. The 75A-3 was introduced in December 1951, giving the A-2 a rather short production run. Next month, we'll examine the 75A-3 and the reason for its introduction: the outstanding Collins mechanical filter. **ER**

The Collins 75A-Series Receivers: A Legacy of High Quality

Part 4, the 75A-3 and Mechanical Filters

by Ray Osterwald, NØDMS
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When the Collins Radio Company announced their new mechanical filter design at the Institute of Radio Engineers convention at New York City in March, 1951, the effect was as if additional radio spectrum had been discovered. Not only was a new high standard of selectivity introduced, but the final link had been forged between an engineering concept and practical, low-cost single-sideband radio equipment.

Collins did not discover the principles of magnetostriction. These had been known well before the radio era. In 1878, Lord Kelvin wrote about the changes which occurred in the field of a magnetized iron wire when he applied controlled mechanical strains to the wire. Magnetostriction, was discovered some time later by an English scientist, Shelford Bidwell. In 1886 he described how iron nickel and colbalt wires changed their length when surrounded by varying magnetic fields. He was able, with a system of levers and mirrors, to measure a total change of one ten-millionth of the length of his sample materials. In our century, oscillators having their frequency controlled by magnetostrictive rods were first described by G.W. Pierce in the Proceedings of the American Academy of the Arts and Sciences for April, 1928. In this paper, Mr. Pierce discussed various types of magnetostrictive metal rods, among them monel, nickel, stainless steel, invar, stoic metal, nichrome, and other nickel alloys. These rods later became an essential component of mechanical filters. (This is the same Mr. Pierce who invented the Pierce crystal oscillator.)

Modern radio handbooks typically have a brief description of mechanical filter design, stating that there is an input transducer, resonant filter disks, and an output transducer. They are actually much more interesting than the space for these brief descriptions allows. When it is mentioned that the filter disks are resonant, it must be remembered that this is mechanical, not electrical resonance. At a typical IF frequency of 455 Kc, a free-space electrical half wavelength is 1,030 feet! The mechanical wavelength for that same frequency is much shorter than its electrical counterpart because mechanical vibrations have a much lower velocity of propagation. Therefore, a compact, high-Q filter may be built with half-wavelength physical dimensions and the same properties as an equivalent half-wave electrically resonant transmission line would have. That's what gives the mechanical filter its extremely narrow passband. The disks are merely mechanically resonant pieces of metal, and the filter bandwidth is set by the accumulated diameter of the disk coupling wires. In Figure 2, short lengths of coupling wire may be seen near each end of the filters. These are actually mechanical impedance transformers.

"Magnetostrictive" materials will expand and contract with changes in a nearby magnetic field. If we connect a signal source to a coil having a magnetostrictive metal core, mechanical oscillations are formed. If we attach that core to a series of resonant disks, a basic lattice filter is built. The more disks in the filter, the higher the loaded Q becomes. Perma-

Figure 1, the Collins 75A-3 receiver.

nent magnets are glued onto the transducers. These magnets provide a small magnetic bias which prevents the transducers from producing a second harmonic response. To visualize this action, a similar mechanical bias could be set up in an old style magnetic earphone with a steel diaphragm, if the plate was only allowed to bend in one direction.

The Collins mechanical filter was not developed overnight, but rather was the result of five years of hard work. The project began in Cedar Rapids in 1946, assigned to an engineer named Melvin Doelz. Only the initial research was done in Iowa, however. Early on, the project moved out to the Collins facility at Burbank, California, where most of the final development and all of the production took place. In fact, Rockwell still runs production on the filters out there, annually turning out between 3 and 5 million of them.

Mr. Doelz, who is not a licensed amateur, is a very friendly person who readily agreed to be interviewed for this article. He is still actively employed in engineering, and should be credited with the invention of the first successful mechanical filter. By agreeing to the interview, he has provided ER readers with much valuable background information unavailable from any other source.

I asked Mr. Doelz for not only the technical details of the mechanical filter design, but also for an outline of the steps which lead to a successful product.

As he described it, "Art Collins had been working on the single-sideband project at about this same time, developing the first single-sideband gear. He had a bunch of engineers in Cedar Rapids working nights and everything. He viewed the filter, and I think appropriately, as one of the key moves to making single-sideband practical on a commercial basis. The other filters were too expensive, so it became an integral part of the single sideband project. Bob Olsen, a young engineer who moved out to Cali-

continued next page

fornia to join us, worked on it a lot, particularly in the production phase. I did the development work myself, and had patents granted in several areas. I think there were more than two patents, some original ones which described the original configuration, and then there were some others granted for improvements, such as the ferrite transducer and some other things. Collins, at the time, had an in-house patent attorney. He liked to patent everything in sight."

Mr. Doelz said that RCA engineers started working on a post-war design for a mechanical filter before he did. RCA used fragile, thin, flat plates instead of the disks used in the Collins filter, and point-to-point welded wires connecting the centers of these plates. (The "Campbell" mechanical filter was described in the RCA Review for September, 1949, by RCA engineers Roberts and Burns). The RCA filter was a mechanical lattice structure, but was so fragile that Doelz and his associates couldn't use it. Not to be discouraged, he started looking around for a reasonable alternative. One day he came up with the idea of possibly using a disk to replace the thin plates. As he envisioned it, the disk would have a circular vibrational mode similar to a drumhead. The disk coupling wires could then be welded around the edges of the disks instead of to the centers of fragile plates. The entire filter structure would then be much stronger.

He began building the filter with a drill press and hand tools down at the Burbank Plant on Saturdays. He would cut a disk, grind it out to rough dimensions, and finish sizing it with emery paper. This was a slow, laborious process which required measuring the resonant frequency of the disk after every little bit of sanding.

Eventually the resonant disk requirements became known. By mid-to-late 1947, Mr. Doelz had a prototype filter. In the interim RCA gave up, leaving the field wide open for Collins to move ahead.

The mechanical filter turned out as good as Mr. Doelz expected it to be. The disks, due to their circular mode of vibrations, would run at standard IF frequencies much more substantially than in the RCA design.

Mr. Doelz told me a good story about this early period: "We installed one of the first ones into a Collins receiver we'd modified. I forget if it was the amateur or the commercial version. We stuck the filter in one and it worked fine of course. I remember we put a new label on the receiver and called it something else. Mr. Collins happened to stop out there on a trip, and we showed it to him. He thought it was great except he wasn't very fond of the label we'd put on the receiver. We'd just picked some number, and he was a little touchy about the numbers."

Getting a few engineering samples was relatively easy. A far more formidable task, getting efficient production going, lay ahead. They had to find disk materials with a zero temperature coefficient, and a workable magnetostrictive material for the transducers. Production machinery had to be designed from scratch and then tested. Technicians had to be hired and trained. Melvin Doelz's associate, Bob Olsen, was instrumental in getting past these critical phases.

As Mr. Doelz described this early period, "a lot of the development work, actually, the important work was involved in getting it so you could build the things in quantities with good yield. It was relatively easy, and fairly quick, to get some models out that worked. We put a lot of effort into getting the production line going. It was really a question of 'yield'. We started out with maybe 20% yield, and got up to 80 or 90% yield. We developed automatic machinery for measuring the resonant frequency of the disks. The alloy that's used is slightly magnetostrictive, so we could hit them with a magnetic field and they would ring, and we'd measure that frequency. We got a surplus coin sorting machine, the kind that you shake and the coins drop out. We tied it to a channel, and the disks would come

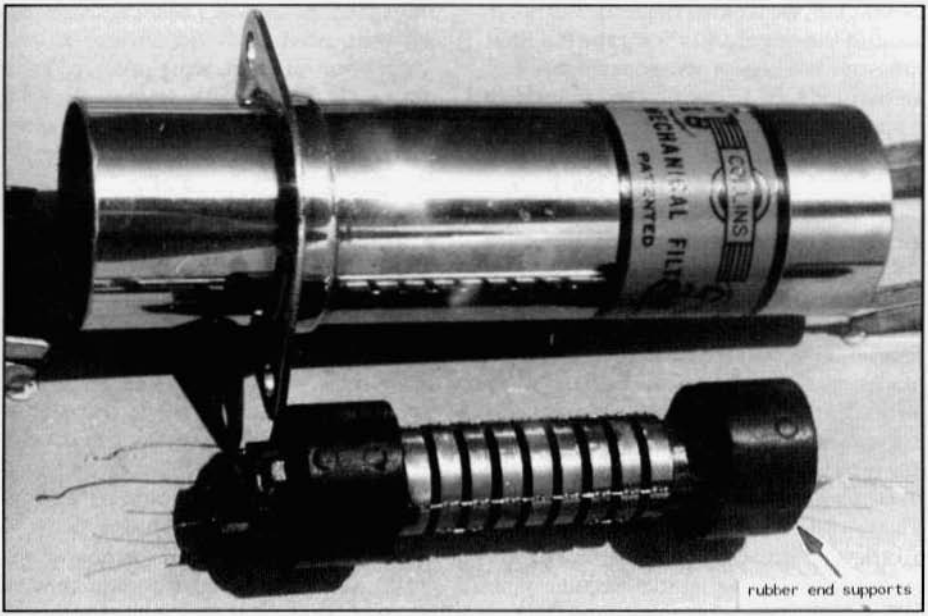

Figure 2, R-390A mechanical filter.

rolling out one at a time. There was a pick-up arm for each frequency range, a band of maybe 50 cycles. The disks would come down and the machine would automatically sort them according to frequency.

"The disks were made from Ni-Span C, a special alloy. There's another alloy that's used sometimes, Invar. The Ni-Span C was better for our purposes. We had to get it in batches of one ton, but one batch would last for several years. Ni-Span C was an alloy that had been developed for watch springs, and had a very low temperature coefficient. You need, of course, something that doesn't change its resonant frequency with changes in temperature. I found it when I was at a trade show, talking to some steel specialists from U.S. Steel. They had developed this special metal, and they were the only source and we were their only customer! We would go to them every couple of years or so, and they would stir up a batch of this stuff in one of their furnaces and ship it to us. It came in rod form. The steel company rolled it out to about the right diameter, and then we centerless ground the rod, cut it off, and then surface ground the disks to precise mechanical dimensions. Each batch had a slightly different characteristic. We had to do quite a bit of adjustment of production parameters, as there were spurious resonances showing up outside of the main passband, maybe going out to 40 dB below the passband. Every time we got a new batch we would have to readjust the parameters to fit the new batch.

"The trick to begin with was to get them close to the right frequency. We bought some fairly expensive equipment to do that. We had a big surface grinder that we used, and we got them down probably as close as you could get with ordinary machine methods.

"We also used a spot welder to weld the nickel coupling wires around the edge of the disks. It wasn't a special one, but we did a lot of work getting the right amount of current to get the right heat. That was a somewhat tricky, precise operation because we were welding pure nickel wire to the dissimilar disk material.

"When we had the filter completely

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Collins 75A-Series from previous page
assembled, we welded the coupling wires around the edge, and then gave it a final tune-up. We used a swept oscillator and an oscillograph to display the frequency response of the filter. The girls would look at that display, and they used a dentist's drill to make the final adjustment of the disks which needed it. Every girl had a drill at her station.

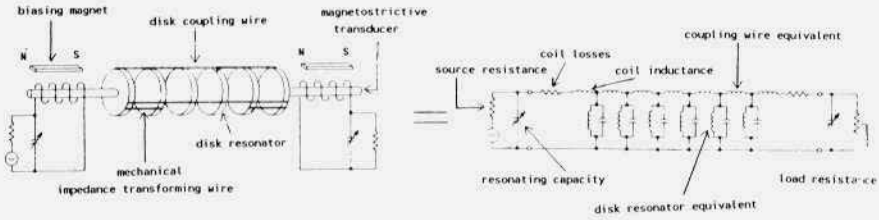
"If you think of the filter disk vibrating as a disk solid, it had a vibration mode where there were two stationary rings. Incidentally, you could see the vibration mode on the disks by sprinkling them with licopodium powder. Even at 455 kilocycles, you'd put the licopodium powder on a disk, and it would gather at the fixed locations on the resonance 'rings'. They would raise the frequency by taking a little off the edge, which reduced the mass that was moving in a circular manner at high speed. They lowered the frequency by drilling out and removing a little at one of the resonance rings, one of the static rings, which is where the material was flexing.

"We were moving in the other direction, increasing the compliance of the metal by drilling out near one of the rings. In an over-simplified fashion, think of a weight on a spring. As they drilled out the material on the ring, it was equivalent to weakening the spring, and as they drilled out the material on the edge it was equivalent to reducing the mass of the weight moving in a circular mode. Metal was removed to either raise or lower the disk's resonant frequency. The disks were pretty good to begin with, but we would trim them up a little bit, get them within the specs if they were out. I think the specs were one and a half dB ripple across the top of the filter passband.

"We used two types of drivers (transducers) for the filters. One of them was just a piece of annealed nickel wire that was butt-welded into the center of each end disk. Nickel is a good magnetostrictive material. There are a couple of coils that slip into a tube that's attached to the filter at the two ends. The nickel wire was self-supporting within these tubes. There's some careful work involved here, obviously. The nickel was very soft. If we bent it much it lost some of its magnetostrictive property, so we had to anneal it and handle it very carefully. That nickel wire was resonant, as I recall, at one and a half wavelengths. There were really two coils in each transducer, it looks like one, but there were two of them producing magnetic fields in different directions at two nodal points on the wire. The trick, of course, was that we had to get the loading on the mechanical ladder filter equivalent to the resistive load at the end of the electrical ladder filter. This magnetostrictive material, this pure nickel, had a very low "Q", about 20 or something, so it provided the necessary loading, in addition to being a transducer to convert electrical energy to mechanical and back again. Those filters had losses of 15 or 20 dB throughout.

"We had another type of transducer, in some of the larger filters, in which we used a ferrite rod that was cemented to a piece of wire that was in turn welded to the end disk. The ferrite rod was a much more efficient transducer, and we got down to losses as low as 3 dB. Both systems worked, and in an IF, a 20 dB loss wasn't too bad, because we had the signal boosted to a fairly high level before it got into the filter. (There is a good photo of a filter with ferrite transducers in the Collins book, *The First Fifty Years*, page 111.)

"There was no bandwidth trade-off between the two types of transducers. The filter bandwidth was determined entirely by the accumulated diameter of the outer coupling wires. The lower the diameter, the narrower the bandwidth, and the higher the diameter the wider the bandwidth. The resonant frequency of the disks alone determines center frequency. If the filter is not loaded down (if a load hasn't been supplied one way or another), what you see is over the bandwidth of the filter, and classic theory will tell you this, is a



Mechanical Filter **Electrical Equivalent**

series of sharp peaks, the same number as the number of disks in the filter. A five-disk filter would have five peaks, more or less equally spaced, with great big holes between them, maybe 40, 50, or even 60 dB down. That's a filter without its load. If the load is put in, the valleys fill up and make a nice smooth passband. You don't change center frequencies by anything you do with electrical termination."

In addition to the formal introduction at the above mentioned IRE show, mechanical filters were the subject of a four-page article in the Collins company magazine *Signals*, for Summer, 1952. This article is mostly good company photographs of the filter construction, and photos of installation into a 75A-2A. There is an IF response curve comparing conventional VS mechanical filter response, but not much more text over what is given in typical receiver instruction books.

QST ran a three-part article, "Magnetostriction Devices and Mechanical Filters", by Walter Van B. Roberts, W2CHO, of Princeton, New Jersey, June to August, 1953. Mr. Roberts was one of the authors of the original RCA article in 1949. This series is a very detailed description of the basic principles, and of the possible uses of magnetostrictive ferrite devices. It concludes with a construction project, including dimensions, of a filter based on the old RCA design. This is a very impractical article, as most hams are not able to build their own watches, either!

With the introduction of a workable mechanical filter, the picture of a modern receiver was at last complete. When Collins announced the 75A-3 in December, 1951, we entered the modern communications receiver era, having come a long, long way in the 61 years since Sir Oliver Lodge revealed his "coherer" detector in 1890. For the first time a receiver was available that was essentially drift-free, had truly sharp selectivity and super sensitivity, was accurately calibrated, and relatively compact.

Commercial customers had the filters available as add-on kits in the 51J-series receivers, and the military got them in the R-388A with a plug-in IF adapter. Also, for the military efforts, they were designed into the IF subchassis on the new R-390A receiver. They started to show up in new transmitter design as well, and were used to reduce transmit band width, which in turn reduced wide-band noise.

The 75A-3 Electrical Design

Lou Couillard's 75A-2 was turned over to engineer Gene Senti in mid-1951 for an update incorporating the new mechanical filter. Electrically and mechanically, the 75A-3 is virtually identical to the 75A-2, with the exception of the added filters and IF amplifier. Up to the first IF amplifier, there are no changes. The component numbers and values are all the same.

The first IF amplifier, a 6BA6, is used to give the IF strip about 20 dB additional gain to overcome the losses in the mechanical filters. In fact, this stage and its filters are the only significant changes. The next three amplifier stages are entirely conventional, running slightly

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higher gain than before. They use grounded cathodes in favor of cathode bias resistors as in the A-2's design. The IF transformer design was changed, due to the newer, sharper IF response, by using simplified coils and coupling networks.

The only other changes were to the muting diode plate load, and the grid bias on the 6AQ5 pentode output stage was adjusted. Mechanically, an A/B switch was added to the front panel, underneath the BFO pitch knob, so an operator could select IF bandwidths. Everything else on the front panel is the same.

No evaluation receiver was available, so no performance measurements were performed. I would expect no real change from the 75A-2, except the radically new shape factor in the IF stage!

The 75A-3's interference fighters, a mechanical filter backed up by a variable crystal notch filter, are superior to any Q-multiplier or T-notch I've ever used. This holds true for any receiver with this dual combination. Interference is not just deeply reduced, but is gone. It is too bad later receivers did not keep this effective weapon available.

The 75A-3 was produced until late 1955, giving it a production run of over four years. This makes it second in A-line longevity only to the 75A-4. The 75A-4 is still the preferred ham receiver of many die-hards the world over, for reasons which will be examined in the next installment of this series. **ER**

QSL Cards Tell a Tale from page 23

9 SX-99 (Hallicrafters)
9 AR-3 (Heathkit)
7 S-38 (Hallicrafters)
7 NC-98 (National)
6 HQ-129 (Hammarlund)
6 S-85 (Hallicrafters)
5 SX-100 (Hallicrafters)
5 HQ-110 (Hammarlund)
4 S-40 (Hallicrafters)
4 HQ-100 (Hammarlund)
4 NC-183 (National)
4 HQ-140 (Hammarlund)
4 SX-28 (Hallicrafters)
4 S-53 (Hallicrafters)

What was surprising was the Heathkit AR-3 tied for first place! Now, I had one of those and it was barely better than the 5-tube AC-DC broadcast radio in the kitchen. In fact, the only difference was the bandswitching and extra coils and a power transformer for safety. OK, it did have bandspread tuning. It was cheap, however, and I suppose the marketing effect called "drag" where one popular item induces sales of other products from the same manufacturer, must have been at work here, too.

What was totally off the wall was to see that the most popular item mentioned in the receiver blank on the cards was not a receiver at all, but the Heathkit QF-1 Q-multiplier: at least 13 times. It helped increase the selectivity of mediocre receivers and certainly all the AR-3's needed one (plus some of the low-end models from the other manufacturers). I might mention that having only used the AR-3 when I was first a ham, I was completely overwhelmed by the performance of a Drake 2B that I got recently to reenter ham radio after a 30 year hiatus. No Drake equipment was mentioned in any of the cards, although I do recall one friend getting one just as I was going dormant. That was just about the time SSB was becoming popular.

What else? Well, there were 5 YL or XYL hams in the group of 151 cards. Not many, but more than I have heard on the bands since resuming activity. And there were more teenagers then. There were many personalized comments on the cards, too, often about topics from the QSO. And then, some of the cards were handmade or custom printed and just neat to look at. Too bad QSL cards don't seem to be as much a part of ham radio as they used to be. **ER**

The Collins 75A-Series Receivers: A Legacy of High Quality

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Part 5: The 75A-4 and the Single-Sideband Era

Why is it that a ham receiver first produced thirty-seven years ago, in terms of basic receiver performance, is still fully competitive with contemporary designs? What is there about the 75A-4 that makes it so intrinsically "radio" that their owners become very unwilling to change? Is it because the A-4 may be fixed with only a VTVM and a soldering iron? Is it the feel of the comfortably large and velvet-smooth vernier dial placed at exactly the right height on the panel? Maybe it could be a quiet moment in the shack, when the translucent kilocycle dial is illuminated in the warm glow of a type 47 lamp that we get attached to. Or, maybe it's the big Simpson S-meter we remember, as it kicks up sharply, announcing that the DX station you've stayed up so late for has finally arrived. It also might be the super-sharp selectivity that's available, as fellow net members are quickly separated from band noise. Surely it couldn't be the fact that the rig was made in Iowa, USA, could it? It is probably not one single thing so much as a combination of all its features that produces this devotion.

Designed to be a high-performance, single-sideband receiver, the 75A-4 did not neglect the other modes and operators, and offers equivalent high performance. Being totally new inside and outside, it was nearly 4 inches narrower than previous A-line receivers, and considerably lighter. It began the trend towards smaller and lighter radio equipment.

All of the unique circuitry in the receiver was developed in a special post-war engineering program which was set up and personally directed by Art Collins. By late 1953, this special team had begun to show some good results of the five or so years of work in new circuit concepts and hardware design. Their progress can be followed indirectly today by scanning the Collins ads which were entitled "SSB Engineering Notes" in the ham magazines of the period. Ernie Pappenfus, K6EZ, was a Collins engineering supervisor in Cedar Rapids at the time. His involvement came when, as he puts it, "Art Collins grabbed a bunch of my engineers and assigned them to a special project team that was headquartered in a little metal building behind the Collins main plant. The sideband circuits used in all of the later equipment came out of this group. We developed the product detector circuits, further improved the stability, reduced audio distortion, and did the other things that were required for good single sideband operation."

It should be pointed out that although Collins designed original circuitry and improved existing basic designs, we should remember that it was Edwin Howard Armstrong who gave us the principles of regeneration and heterodyne signal conversion, which are put to such fine use in the 75A-4.

Engineer Gene Senti, WØROW, took designs from the SSB project team and combined them with what had been learned to date with the existing 75A-series receivers, producing what we know today as the 75A-4. Introduced in March,

Collins 75A-4, S/N 5396. This receiver left final test at the factory 6-6-58, and was purchased 1-7-59 by Wendell Fletcher, K6KOJ, at dealer Gil Severns, Hemet, California.

1955, it was, along with the KWS-1 transmitter, the first Collins equipment designed expressly for single sideband service. QST reviewed the 75A-4 in the "Recent Equipment" column for April, 1955. Over the years, thousands of operators have come to develop a great respect for this receiver and for its capabilities.

Mr. Senti, as with all of the great engineers of his time, is relatively modest when it comes to talking about his life's work. He did mention that "When you're working on a receiver, you spend a lot of time in the screen room!" I asked him what the toughest obstacle was that he overcame during the 75A-4 design process: "Well, getting Mr. Collins' OK on it was the toughest! He was very active in the design. He knew what was going on with the project every day, and would be always looking over your shoulder. He would usually try the new equipment out at his house. He had a real nice ham shack out there with nice beam antennas, and I spent many an evening there, making changes that he wanted to suggest—' try this', or 'move that over there', or 'let's try these instead'. (It's obvious that the 75A-4 embodies whatever performance that Art Collins thought a good receiver should have.)"

"Generally, we'd build one or two of what we'd call an engineering breadboard, which was a pretty shaggy looking thing, with resistors pasted on resistors to get values zeroed in. Then we'd build maybe two engineering models, which had basically the same circuit as the breadboard, but were prettier to look at and nice enough to take some pictures of for advertising brochures and so forth. Right off we'd build a pilot run in the factory of maybe 20 to 50 units. Quite often these were sent out to various dealers and friends of Mr. Collins for evaluation. They'd use them for several weeks and

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make comments about them. Also any problems which showed up during that preproduction run would be taken care of. Then, generally we'd build a thousand units at a time on most of the ham gear. That was done in a little factory about 20 miles out of Cedar Rapids, a little farming community called Animosa. The ham gear was put together by farm gals, mostly. They knew how to give you a day's work for a day's pay. They were very good people and were very conscientious. The ham gear was built out at this place right until the 'bitter end'.

"As soon as Rockwell took us over, they figured out that ham equipment was just a loss leader and decided to drop it, and start making money on military contracts. So they dropped the ham gear just like a hot potato, but they kept the service department for a year or so, and then it was dropped too. I pity the poor guys out in the field who don't have any connections and have to scrounge parts. I see the prices of the parts in some of the magazines and catalogs and it is sometimes as much as the equipment cost new!"

In addition to being a new standard of comparison in communications receivers, the 75A-4 also made significant contributions to national defense and to the maintenance of world peace, something not much other ham gear can claim. Shortly after the introduction of the new amateur SSB line, the Collins Radio Company became involved in a very unusual project with the United States Air Force. Known as 'Project Birdcall', this was a joint effort between Art Collins and two Air Force generals, and convincingly demonstrated the effectiveness of single-sideband radio on world-wide communications circuits. Ernie Pappenfus and his engineering department was directly involved in this work. Here are his recollections:

"I went on several SAC (Strategic Air Command) flights all over the U.S., down to Texas, and to some other places testing single-sideband equipment for the Air Force. We operated all bands from a big old Air Force transport plane. On the plane, we had installed a brand new 75A-4 and a KWS-1, into which we had plugged special sets of Air Force crystals to get us on their command frequencies. Collins had set up a big communications station at the engineering building in Cedar Rapids, later called Communications Central. If the Air Force couldn't communicate with their network around the world for some reason, the Cedar Rapids station would jump in and assist them, as we had some high-power transmitters at the time, 50 kilowatt for sideband. The Collins station also assisted on some of the Presidential flights.

"The way these world-wide tests started was because General Curtis LeMay and General Butch Griswold were the Commander and Vice-Commander of SAC, and both of them were hams. They were familiar with the 75A-4 and the KWS-1 equipment, and one day they came over to the plant and talked to Arthur Collins about single sideband. A few weeks later, in the engineering lab, we made a special setup, which used a 75A-4 and a KWS-1 for single sideband service. Later, we did a permanent installation in a big C-97 Air Force plane. The equipment ran on 400 Hertz AC, and worked quite well there. There was no modification necessary to the power supplies to run at that line frequency. Eventually, SAC dispersed that plane all around the country, and then later to Turkey, Spain, and way out into the South Pacific to test single-sideband. They would have a radio roll call every hour to make sure they had communications, because at that time we had airplanes in the air with atomic bombs on them that had to be ready to go at any minute.

"On most of the test flights Art Collins was along with them, as he was a licensed pilot and interested in aviation. After two dead stick landings with his Bonanza, he decided that he wasn't going to be flying any more!

A 75A-4 and KWS-1 aboard an aircraft during the period when the airforce was evaluating SSB for military use. Photo courtesy of Harry Snyder, WØRN.

"The whole single sideband Air Force program started because of the 75A-4 and KWS-1 we installed on that SAC plane. We demonstrated the equipment, and they realized just how far they could talk with single sideband, compared with the old stuff they had. They decided that they really had to have it in order to have command and control of their airplanes while in the air. I think single sideband and the 75A-4 probably kept us out of a war.

"The Collins airborne installation was used for a couple of years, I think, starting around late 1955 or early 1956. After they saw how successful it was, the Air Force let a contract to Collins to develop the high power transmitters and the specialized communications equipment they needed, including the ARC-58, which was a single-sideband, multi-channel airborne set that we made thousands of.

"As far as I know, there were never any green 75A-4s for the military. As far as I can remember we never painted any a different color, and none of them was specially built under mil spec."

75A-4 CIRCUIT DESIGN

The 75A-4 is crammed full of circuit goodies originally developed out in that little tin building at Cedar Rapids. From Ed Andrade's product detector, to Gene Senti's passband tuning, the 75A-4 introduced circuit concepts still enjoyed in more modern equipment. It really represents an entirely new design philosophy from the rest of the A-line receivers.

The 75A-4 front-end represents a major design philosophy change from any other HF receiver of the period. The Collins SSB

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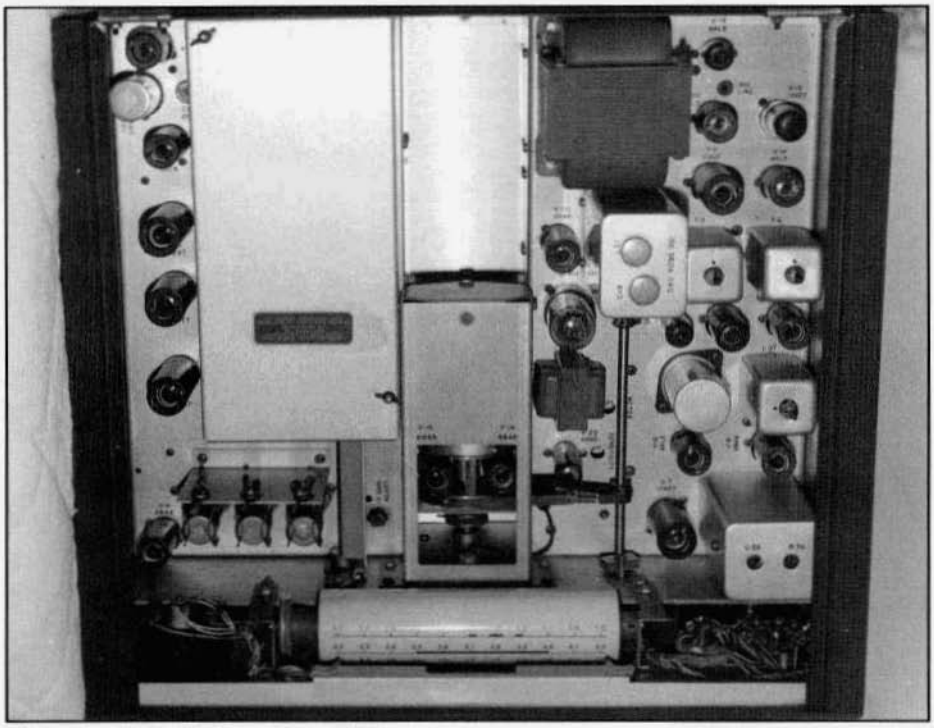
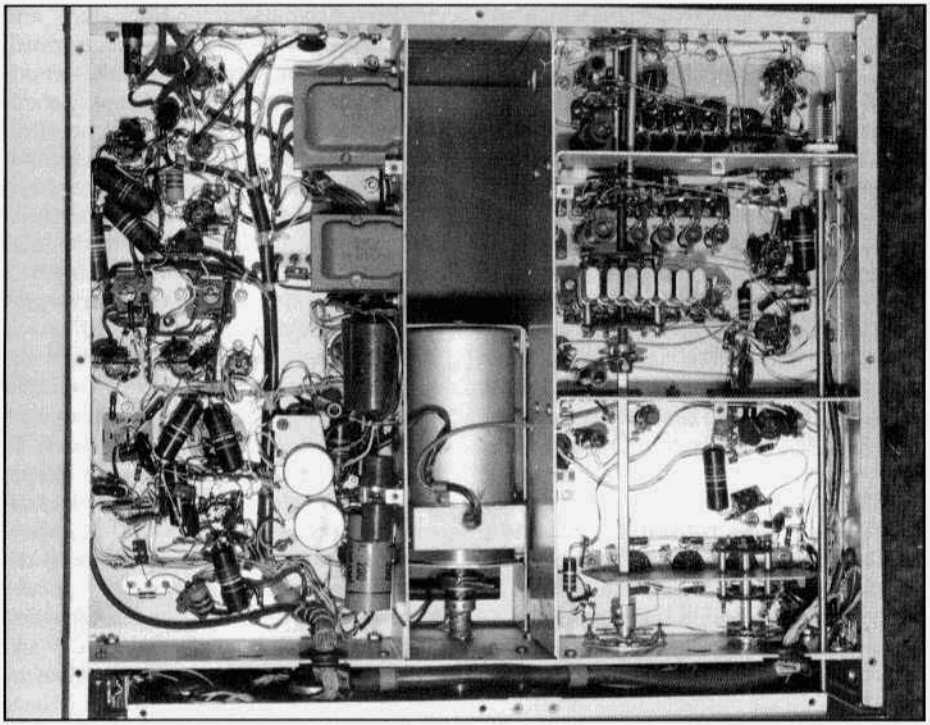


Underneath the 75A-4 cabinet lid.

project team recognized that given typical noise levels, a 7-to-10 dB receiver noise figure is perfectly adequate 90 percent of the time, even on 10 meters. Therefore, extreme sensitivity was traded off for the higher dynamic range figure needed in the increasingly crowded HF radio environment. This was accomplished with the 6DC6 pentode amplifier, the standard front-end tube for Collins until the S-line was discontinued. The remote cut-off 6DC6 was developed for television receiver front-ends, where similar problems with IMD were encountered. The 75A-4 is 14 dBm less sensitive than the 75A-3 or 75A-2, at -127 dBm. However, the dynamic range has improved significantly. My evaluation receiver, in factory stock configuration, measured a blocking dynamic range of 90.2 dB. The 2-tone, third-order dynamic range measured 88.3 dB. These numbers confirm what is already known, that the 75A-4 is in the "high-performance" class of receiver.

Another significant change is the inclusion of a built-in 100 Kc. calibrator, which uses a 6BA6 in a modified Pierce crystal-controlled oscillator. A Pierce oscillator operates in the parallel-mode for stability. The oscillator portion of this circuit is actually a Pierce "triode", in which the pentode screen serves as the equivalent triode "plate". The cathode and suppressor are bypassed to ground, forming an electron-coupled oscillator, which prevents changes in the plate load from pulling the oscillator frequency. This calibrator has good short-term stability. Although the crystal is mounted in a sealed can and uses a ceramic socket, long-term drift is a problem, and the calibrator must be frequently re-set. There have been some modifications published to increase the calibrator marker level on the 10 and 15 meter bands by directly substituting a 6BZ6, and this works well.

In order to have the same tuning rate



Bottom view of the 75A-4. The cabinet serial number reads 5396. Other records indicate a "factory serial number" of 5-396 and a "customer serial number" of 396. This might be part of the reason S/N's are not sequential.

on 10 meters as on the lower bands, an additional position on the bandswitch was added, giving a 10 meter "low" and a 10 meter "high" selection. The low portion tunes 28-29 Mc., and the high portion tunes 29-30 Mc. This requires an additional bandswitch deck in the RF amplifier plate circuit because of the added trimming capacity, and an extra crystal position was required for the 1st crystal oscillator grid and plate circuits. Also, the 10 and 11 meter bands were given their own antenna coils, to further increase image rejection.

In connection with the additional 10-meter switch position, the 1st variable IF bandpass is now 2.5 to 1.5 megacycles on all bands. 6BA7's are retained as the first and second mixers, and the double-tuned first mixer output is unchanged from the earlier receivers.

A newly-designed PTO, a type 70E-24, was used in the 75A-4. Its electrical design is similar to that of the others, but it is stronger mechanically, and critical component selection provides even higher stability than before. Its output range is 1.955 to 2.955 Mc., to produce a fixed 455 Kc. IF from the second mixer.

The 75A-4 design fully integrated mechanical filters into the IF amplifier strip, by allowing up to 3 of them to be plugged into chassis sockets, and to be selected from a front-panel switch. In contrast to the military receiver designs, there are no ceramic trimmers on the filter terminations in the 75A-4, probably a cost-saving measure. To make up for filter insertion losses, a 6BA6 pentode amplifier directly follows them.

Following the fixed selectivity provided by the mechanical filters is a variable

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notch filter, of a new design which replaced the venerable crystal notch of the 1930s. This new filter uses both halves of a 12AX7. The first half is a cathode follower which is used to feed a regenerative amplifier, the second half of the tube. The cathode follower serves to buffer the amplifier's input voltage. The regenerative amplifier has a variable bridged-T filter in its plate load, and being a series-tuned circuit, it provides a deep null at resonance.

Normally, a variable bridged-T filter won't provide a deep notch when used in IF circuits above 100 Kc. However, in the 75A-4 circuit, the effective Q of the plate filter coil (L26) is raised by means of the Q multiplication action in the regenerative amplifier. This gives an effect similar to a crystal notch, but avoids the distortion which is so typical of the IF response curve on either side of the crystal notch. The adjustment resistor, R36, gives the deepest null when set at 1/4 of the resonant impedance of the tuned circuit.

Unfortunately, due to short-term drift of the filter components, a careful alignment of the rejection filter circuit to provide the deepest notch usually doesn't last too long, and the long-term effective notch depth is less than what was available with the 75A-3's crystal notch. Hand-selection of C73 and C74 to provide the lowest possible temperature coefficient will help, but they are inside the filter can and are hard to get at.

As if a sharp rejection notch working against the steep skirts of a mechanical filter wasn't enough, Mr. Senti also gave us mechanical "passband tuning". This is a scheme where the rear of the PTO can is mounted in a bearing, and connected via a flexible metal strap to the shaft of the BFO tuning condenser. When the operator moves the passband tuning control, he can change the position of the interference relative to the fixed mechanical filter skirts, without changing the beat note or the dial frequency. There is no separate BFO pitch control. The effect is to "shove" interference outside the filter skirts, and it is extremely effective when the system is in proper alignment. Note that in this arrangement, in sharp contrast to modern passband tuning circuits, no additional RF conversion stage is required. With no additional mixing, there is no chance for additional distortion products to show up, and all we get are the benefits of the selectivity! Passband tuning was first used on the 75A-4. Its invention should be credited to Gene Senti.

There are two stages of conventional 455 kc. IF amplification. In many modification articles, it is advised to change the value of R46 to 47K, and R50 to 68K to increase IF gain. If this is done, be sure to change R47 to 1 Watt. Be aware that total receiver gain distribution will be affected.

Gene Senti provided deluxe dual detectors as well. Not only is there a tube diode for AM detection, but Ed Andrade's product detector is included for CW and SSB. Its interesting to note that in all of the modification schemes I've read, not once did anyone mention changing the product detector because it works so well as designed.

After the detectors is a dual-diode audio noise limiter, which is adjustable from the front panel and clips on positive and negative peaks. It is effective on AM, but unfortunately it is all but useless on CW and SSB. There were many "fixes" offered over the years, and it was even the subject of a multi-page Collins service bulletin. In short, what they said was that noise pulses are simply stretched out in the selectivity so much that by the time audio limiting is reached, limiting action is ineffective. After catching heat about this problem for several years, Collins released the type 136C-1 noise blanker for the 75A-4. Using a separate 40 Mc. receiver to convert noise impulses to IF blanker pulses, it works OK, but is nearly impossible to find. The blanker was reviewed in QST November, 1959, and was also used in the KWM-1 and KWM-2 rigs for ignition noise suppression in vehicles.

Amplified AGC is used in the receiver. A sample of the IF voltage is picked off after the second IF amplifier and fed to an IF AVC amplifier. Following the amplifier is a dual diode. A small DC bias voltage is placed on the detector half to provide delayed AGC action. The second half of the detector tube is used as an IF AGC noise limiter. By clipping the noise pulses before detection, they are prevented from charging the AGC line and reducing gain during the noise pulse duration. In spite of precautions, there are several problems with the AGC, and they will be discussed later.

Instead of the RF gain control being a simple voltage divider across the AGC bias line, a separate bias rectifier and a "gain gate" was added. In the previous designs, changes in the RF gain control setting would not only change the impedance of the AGC line, but also would change the gain distribution in the controlled stages. In the 75A-4, using a separate bias rectifier provides an isolated, low-impedance AGC line, which further minimizes blocking and distortion with strong signals. To visualize its action, a higher impedance line would form a longer time constant with the AGC bypass capacitors. This longer time constant would mean that a controlled stage might be driven into distortion before the AGC could respond to prevent it. The gain gate, the second half of the bias rectifier tube, decouples the RF gain control from the AGC line. This is done so that the receiver's gain distribution is not disturbed by changes in the RF gain adjustment. Gain distribution is critical in keeping all of the controlled stages operating in their linear regions. Changes such as these came directly from the SSB special projects team at Collins, and Gene Senti's insight into what Art Collins would approve of.

To top off the design of this completely new receiver, the audio section was redone. The 6AQ5 single-ended output stage was retained, but it is now driven from a two-stage triode preamp. Both halves of a 12AT7 are used to drive the output tube. To reduce distortion on signal peaks, the 6AQ5 grid bias is taken from a much more elaborate resistive voltage divider network. There is additional RF by-passing, and if all of this wasn't enough, negative feedback was added to further reduce distortion. A sample of the output transformer secondary is picked off, and applied via R71 to the cathode of the first audio preamp, giving roughly 15 dB of inverse feedback. This helps to smooth out the audio response, and to reduce the effect of DC core saturation on audio peaks, common with small audio output transformers. Some modification articles recommend changing R71 to 100K to reduce the feedback, and to load the audio gain pot with a 1 Megohm resistor to further linearize it. I've never found these to be too useful, but they are fun to try.

CONCLUSION

Due to space limitations, there will be one additional installment of this series which will deal with the many modifications published over the years. Hopefully this will serve as a guide to readers wishing to change their receivers.

The 75A-4 was produced until mid-1959, when it was discontinued in favor of the 75S-1. This brought the Collins A-line equipment to an end, in the natural progression of technical development. The intent of this series of articles has been to provide a clear picture of these receivers, and of the times they were produced in. Surely they will stand as some of the classic communications receivers of all time. **ER**

The Collins 75A-Series Receivers: A Legacy of High Quality

by Ray Osterwald, NØDMS
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Part 6: 75A-4 Modification Summary

75A-4 Modifications

If the reader is looking for a set of step-by-step instructions on how to do a 75A-4 'hack job', thereby turning it into some cold, dark, solid-state blob, he'd better look elsewhere. Vintage technology certainly does not deserve such crude treatment.

Over the years, there have been many different circuits published dealing with 75A-4 mods. I've tried a lot of them, and they have ranged from worthless to outstanding.

Readers should be aware that the only modification that's really necessary is the AGC and coupling capacitor mod per *ER*, May 1990. The rest of the receiver works just fine as it is. The W2VCZ front end mods listed below make an incredible difference, but without the proper tools, test equipment, and experience I would advise against tearing into a perfectly good 75A-4.

The following is a chronological list of modification articles which have appeared in the magazines over the years. This list is probably not complete, but is the best list that I have:

12/14/55 Collins 75A-4 Service Bulletin #1, 3 pages:
Improving noise limiter action (it really needs it!)
Revise Q-Multiplier
Eliminate random fuse blowing
Keeping RF out of muting circuit
10/15/56 Collins 75A-4 Service Bulletin #2, 10 pages:
"S" meter pot replacements
Hum reduction
Noise limiter modification & long discussion of noise pulses
5/31/57 Collins 75A-4 Service Bulletin #2A, 2 pages
More on "S" meter pots and replacements
9/18/57 Collins 75A-4 Service Bulletin #3, 1 page:
Elimination of RF pickup in standby
(I don't know if there are more Collins bulletins than these.)

QST, 5/58, p.76: Audio Muting for 75A-4
Ok, if you need to do it.
QST, June 1959, p.60: Panadapter Connection for 75A-4
CQ, April 1960, p.32: 20 Kc Filter Adapter and SSB IF Noise Limiter
(adds new 20-Kc IF strip for selectivity)
CQ, June 1960, p. 81: 75A-4 Modifications
Change 2nd mixer to 6U8A.

QST, June 1960, p.16: 75A-4 IF Noise Limiter
An SSB pulse clipper that works!
CQ, June 1960, p.42: An SSB IF Noise Limiter (using a 75A-4)
CQ, November 1960, p.62: Addendum to the 6/60 CQ article
CQ, June 1962: 6U8 second mixer modification
CQ, November 1962, p.77: Update The 75A-4
12AT7 first mixer, 6U8A second mixer.
Short article, not much explanation of mods
CQ, May 1963, p.60: 75A-4 Receiver Improvements
6BZ6 RF amplifier and 6U8 2nd mixer mods. Short article.
QST, May 1963, p.55: Improving the CW Selectivity of the Collins 75A-4
Plug-in 500-cycle crystal filter mod for CW. Good article.
QST, July 1964, p.18: 7360 Mixers in 75A-4
Classic article on beam-deflection mixers in 75A-4. See comments below.
CQ, June and September, 1965: Improving the 75A-4 on SSB
Dual-Triode 1st mixer, 6U8 second mixer, various AGC mods.
QST, November 1966, p. 53: Station Design for DX
Gives a short listing of the more popular A-4 mods of the time.
Be careful, some of these are goofy, such as drilling holes in the receiver bottom plate to compensate for dried out lube in the PTO.
CQ, July 1967, p.22: A 2.1 Kc Filter for the 75A-4
Inexpensive Lafayette mechanical filter for A-4.
W2VCZ, October 1967: 75A-4 Conversion Schematic (publication unknown)
This is the circuitry preferred by almost everyone. See comments.
Ham Radio, April 1970: Improving Overload Response in the 75A-4 Receiver.
Very complete, well- written article, with measurements and adjustments. Changes first and second mixers to greatly improve dynamic range.
Ham Radio, January 1971, p. 67: 75A-4 Modifications
Weak article describing various problems and changes.
Ham Radio, April 1972, p. 68: 75A-4 Hints
Cal. oscillator mods.
73 Magazine, April 1972, p. 68 75A-4 AVC modifications
Questionable value.
73 Magazine, February 1973, p.105: Economy Filters for the 75A-4
Plug-in 500-cycle mech. filter and L-C 6 Kc. AM filter mods.
Ham Radio, December 1974, p. 24: Making Your Collins 75A-4 Perform Like New
Excellent article by Bill Orr, W6SAI, on PTO maintenance.
Ham Radio, September 1975, p. 58: 300-cycle crystal filter for Collins Receivers.
OK article, but the filter is now hard to find.
Ham Radio, September 1975, p. 63: Collins 75A-4 Mods
Good, short summary of what works for DX'ers, by W9KNI.
Ham Radio, November 1975, p. 70: Increased Selectivity for Collins 75A-4
Short article by Jim Fisk (W1DTY) to replace IF transformer with 2.1 Kc filter. Also some minor info on resistor changes.
Ham Radio, April 1976, p. 43: 75A-4 Noise Limiter Noise
How to disable 6AL5 noise limiter. Not much good.
QST, August 1978, H&K: Collins 75A-4 Oscillator Dropout
Worth looking up. Good tips and some factory-advised checks.
Electric Radio Magazine, May 1990, K7CMS: Collins 75A-4 Modifications
The best AGC mod ever published; in use at NØDMS. Gives the 75A-4 the same fast-attack and slow-decay characteristic as imported rigs have, and reduces distortion.

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If you intend to use your 75A-4 on a regular basis, and not just look at it on a shelf, then the AGC circuit should be modified. On a stock receiver, the attack time is way too long, which allows the front end to go into distortion before the AGC can respond to prevent it. Also, the decay time is too short, which causes distortion between characters on CW and SSB. Switching from "standby" to "receive" charges up the AGC line and blocks the receiver momentarily, which is very irritating. The *ER* mods by K7CMS will take care of these problems. In addition to them, I use 5 Meg at R92 because I prefer a "slow" decay time of about one second.

The other common problem with 75A-4 performance is crossmodulation, or the transfer of modulation from a strong, unwanted signal onto a weaker desired signal. It is most noticeable on CW and occurs directly in the first mixer. There are several easy ways to get rid of it.

Before changing anything, the first step is to check every capacitor in the receiver for leakage. While this is a lot of time-consuming work, it will pay off later by elimination of strange and/or intermittent troubles.

I've heard a lot of questions on the air regarding the use of 7360 beam-deflection mixers in the 75A-4, specifically referring to the July, 1964, *QST* article. This modification has been evaluated at NØDMS.

The irony of beam deflection tubes is that they were introduced too late in the game to compete with solid-state devices, and at a time when the tube industry was running largely on momentum. (The integrated circuit was invented in 1959.) These are "really neat tubes" and most of them were experimentally developed to serve as color demodulators in TV receivers in the late 1950s. The 7360, unlike the rest, was supposed to be a balanced modulator in SSB transmitters. Its technical debut was in July, 1960 issue of the *RCA Review*, in an article by M.B. Knight, a research engineer working in the Receiving Tube Advances Development Department at RCA, Harrison, N.J. High performance, balanced beam deflection receiver circuits could have been perfected without much additional work, but the end of the hollow state era came instead. By 1964, the higher performance, lower cost, and extremely linear 6JH8 had been released. Properly applied, this tube could have given FET mixers a real run for their silicon. 6JH8 performance indicators were largely ignored in the industry, and they saw very limited use before the end came. The 6JH8 does require higher electrode voltages than most typical receivers can supply, making a retrofit difficult.

If contemplating the July, 1960 *QST* mod, readers should expect "sticker shock" when looking up the price of a new 7360. It is a difficult mod to make, with the additional components and adjustments that are required. It should be realized that in this design, the first mixer is not balanced, as you might hope. The author merely switches the second 7360 plate to ground at the rate of the 1st crystal oscillator. What he ends up with is a low-noise, linear pentode mixer with way too much conversion gain. It does eliminate front-end crossmodulation, but there are better and cheaper ways to do this. In his design for the 2nd mixer, I found further problems. He uses the mechanical filter's input transducer in an attempt to balance the signal plates with respect to ground, and recommends adding a 50 uuF trimmer from one plate to ground "if needed" to improve balance. Examining the mixer output with an analyzer, I found that 35 dB of signal imbalance was the best that it got. As built, I could see both RF and oscillator signal in the mixer output. Using both of these 7360 mixers increased overall gain so much that the filters were overloaded, and they were producing spurious signals of their own due to internal distortion. The Q-multiplier was also overloaded, and the notch was reduced to only 20 dB or so. Noise in the receiver was

greatly reduced, which was nice, but there was so much gain that I could hear light dimmers miles away! Needless to say, these mixers didn't last long in my receiver.

The front end mods which I kept in my receiver were adapted from W2VCZ. I made a few changes from his original design, which will be discussed. (These mods give even higher performance than the ones from April, 1970 *Ham Radio*, which would be my second recommendation.) When I first completed them, I thought I'd made some mistake, because the receiver was so quiet. I started tuning around, using a piece of short wire for an antenna. The first station I came across was using a low wire dipole in Italy, and he was loud. On CW, the only signals detected are the ones in the IF passband. The crossmodulation is completely cured. The third-order 2-tone dynamic range improved to 117.5 dB, and the single-tone blocking improved to 110 dB. This is truly spectacular performance.

I don't have a step-by-step procedure available, as most of the work is straightforward. Try to follow the original component layout as far as possible, and pay attention to original lead dress, especially around the mixers.

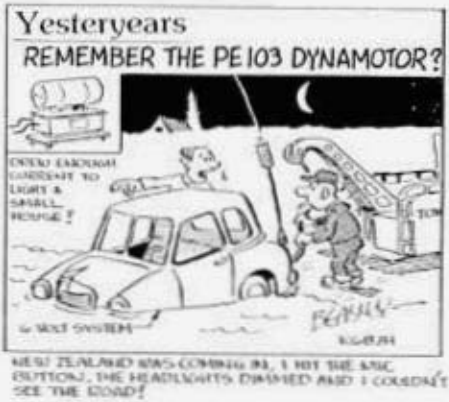
According to figure #1, W2VCZ has replaced the 6DC6 RF amplifier with a type 6GM6. The 6GM6 is a nice front end tube, as it has a more remote cutoff characteristic than the 6DC6, which means it is less likely to be driven into distortion. Its equivalent noise resistance (ENR) is only 447 ohms, 4 times quieter than the 6DC6. The bias needs to be adjusted to provide about -.1 volt with no signal applied, and that's the reason for the 3.3 meg resistors used in the grid circuit. Adding to W2VCZ's design, I have removed C20, and substituted a miniature 10 uH choke in series with the AGC line at pin 1. This was done to provide an even faster AGC response. It further lowers the impedance of the AGC line, but still allows for RF filtering of the AGC line, formerly performed by C20.

There is additional filtering, consisting of a 10 uH choke and a .003-uF condenser in the heater circuits of all the tubes preceding the detector. These were installed after an analyzer across the heater line revealed a terrific amount of intermittent and/or spurious trash, high-level power line harmonics, etc., coming in that way.

W2VCZ used a 6DJ8 twin-triode first mixer. This is an excellent design, with the first section serving as a cathode follower to feed RF voltage into the cathode of the second section. The cathode follower buffers the mixer's RF input against gain changes in the RF stage, and also provides a 50 ohm RF source for the mixer's cathode. LO injection is at the second triode's grid. For this design to work properly, the mutual conductance of the second section must be held down by reducing the plate voltage at the second plate.

Instead of W2VCZ's 6DJ8, I use a 6ES8 as the first mixer. This is a high-performance, frame-grid, low-noise tube, and was designed to be used in premium AGC-controlled TV tuners. At 160 ohms of ENR, it is 8 times quieter than the 6DJ8. It is about the only remote-cutoff triode I know about, and is very hard to overload. It has a cross-modulation factor of just 1% at cutoff with an input signal of 1/2 volt!

continued next page

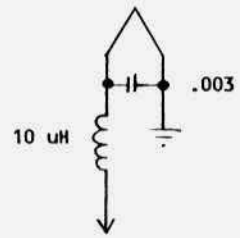


If you use it, try to get the Amperex variety, as they are the PQ (Premium Quality) types with low-resistance, gold-plated pins. There is a high-isolation internal shield; be sure to connect it directly to chassis ground at the tube socket with the shortest possible leads. Try to get the plate voltages close to what is shown, as I optimized them for minimum distortion with a 2-tone RF input.

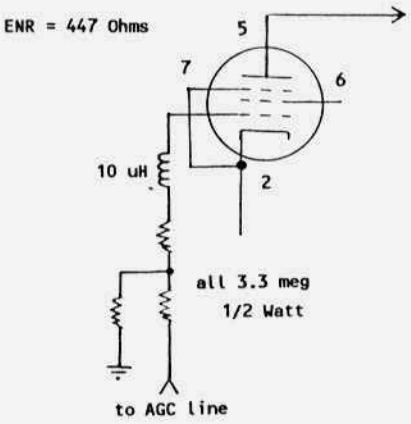
A 6EA8 is called out at the second mixer by W2VCZ. This is the best possible choice I could find, working better than the 6U8 pentode designs published elsewhere. To take full advantage of the low-noise resistance of this tube, a low noise oscillator injection system is needed as well, and it should have a source impedance close to 50 ohms for injection at the 6EA8 cathode. The most troublesome noise in injection oscillators is the broadband "white noise", which can mix to produce spurious signals of its own, also known as "noise modulation". That's the reason for the filter I've added in the LO injection line. The filter is a simple parallel-tuned IF trap. The other change I made was to put 123 volts on the 6EA8 screen. This is an optimum value which gave the lowest value of 3rd-order IMD response. Adjust the value of the 100K series resistor as necessary to get this voltage. The exact value of the resistor will be different from one receiver to another.

I've shown all of W2VCZ's modifications in the drawing. I don't use solid-state rectifiers in my rig.

I'm sure you will like the clean-sounding, rebuilt 75A-4. Its a real pleasure listening to a truly clean receiver, which is free of synthesizer and display noise. Side-by-side comparisons with modern rigs have shown the superior signal-to-noise ratio available with the modified 75A-4 to be a great advantage, especially at a relatively modest station. **ER**



Heater wiring changes



V2 now 6GM6 RF amplifier

OTHER CHANGES:
Remove: R46-R29 in IF stages (see comments)
Add: Silicon diodes in place of 5Y3GT
200 Ohm/10 Watt resistor in C.T. of power transformer
Ground BFO coupling shaft to chassis
R98 to 1 Meg for improved muting
R30 to 56K/2W 1st IF amp screen (see comments)
C112 to .15 uF (AGC time constant)
C101 to .047 (audio coupling)

SPECS per W2VCZ:
noise figure = 4.8 dB at 14.3 Mc.
Sensitivity = .1 uV for 10 dB quieting